

"C.—Attendere placuit ad formam Saturni, eaque exhibita fuit, non quasi adjunctis orbi medio duobus aliis orbiculis, sed quasi adnatis duabus ansulis interceptis maculis, quasi foraminibus effictæ. Heinc forma ovallina, et ea sanè longiuscula, adeo ut medius quasi nucleus vix superaret trienteno totius longitudinis. Fuit autem nonnihil clarior, candicantiorque ipsis ansis. Longitudo semper protensa secundum eclipticam. Habes utcumque heic effigiatum. Diameter Martis apparuit minor sensibilibus diametro brevior Saturni."

"D.—Visi sunt adhuc distinctius Saturni satellites quasi duo cuculli hac propemodum specie."

"E.—Cum ad Saturnum telescopio attendissem medius ille circulus albus non est mihi visus planè exquisitus, speciesque fuit prope hujusmodi."

"F.—Saturnus hujusmodi ferè fuit."

"G.—Saturnus sic se propè habuit."

"H.—Vesperis Parisiis Saturnus rotundus apparuit sine satellitibus clarissimo viro Ismaeli Bullialdo, quemadmodum etiam solitarius deprehensus fuit ab ipsomet Amanuensi mensibus Februario ac Junio telescopio majore Dygbeano videlicet, et minore Galileano."

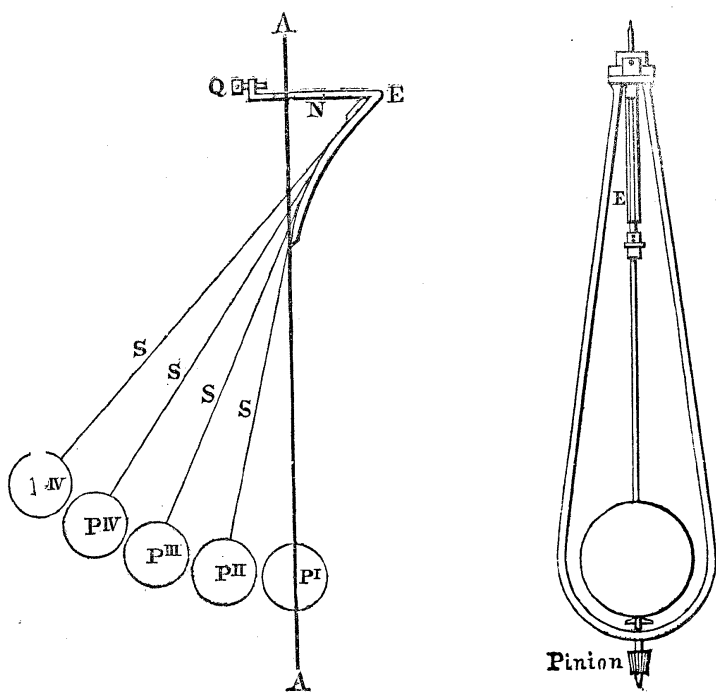
*The Observatory, Crowborough,
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The Results of some Experiments with Huygens' Parabolic Pendulum for obtaining Uniform Rotation. By R. L. J. Ellery, F.R.S., F.R.A.S., &c.

In the course of some experiments I made about two years since with the view, if possible, of obtaining more uniform rotation for our barrel Chronographs than had hitherto been secured, I was induced to try Huygens' revolving Parabolic Pendulum, which appeared so perfect theoretically that I surmised as the reason it had not been more generally adopted that there must be some great practical difficulty pertaining to the application of the principle.

I was somewhat surprised too, on looking into the literature of the subject, to find so little information; and in the books within my reach in Melbourne no record of any experiments or precise trials of this kind of pendulum for securing uniform rotation. I had, therefore, nothing to guide me in my experiments except the bare principle. The earlier results I obtained were so unpro-

missing that my idea that there must be some fatal practical difficulty in the way was strengthened. Eventually, however, I succeeded in obtaining results, and under trying tests, which satisfied me that the pendulum would, with moderately precise workmanship and careful adjustment, become an almost perfect Governor where the variations of force are not greater than we generally have in chronograph trains, or, indeed, in well-constructed and balanced Equatoreals; and in two Chronographs which I had constructed for the Transit of *Venus* observations, and which were controlled by parabolic pendulums, the rotation of the barrels were practically uniform, even when such a variation of the driving weight was made as to produce a difference of 20° in the arc of the rotating pendulum. When I say *practically uniform*, I mean that, on a barrel rotating once in a minute for two hours and a half, *all similar second marks* were in an absolute straight line, and that with a fine drawing pen and a straight edge a line could be drawn accurately bisecting each second mark; in other words, its secondary rate was not a tenth of a second in two hours. As the principle of Huygens' Parabolic Pendulum may not be generally known among our members, I would beg to refer to these diagrams:—



Let A A be a vertical axis of rotation which can be driven by clockwork acting at the top or the bottom of the axis; from this axis a pendulum P is suspended in such a way that when it hangs vertical the string S lies wrapped over a curved surface E, which forms part and parcel of the vertical axis. This curve

is the evolute of a parabola, whose distance from vertex to focus is half the length of the required pendulum. Now let the axis revolve and the pendulum will fly out from its vertical position, more or less according to its weight and the driving power; the arc described by the pendulum, as it increases its distance from the vertical, will be a parabola, by reason of the string gradually unwrapping from the evolute E. Now, from the properties of the parabola, it follows that the vertical distance between the centre of rotation of the pendulum P and the intersection of the string S with the axis of rotation of the pendulum will remain constant, and therefore that the length of the pendulum remains constant at whatever arc it may rotate.

To practically secure these conditions it is necessary, first, that the evolute shall be properly and precisely made, and secondly, that it shall be so adjusted that the axis of the evolute and involute shall be coincident with the axis of rotation.

The pendulums I had constructed are *half seconds*, that is, rotating once in a second. They are suspended in a hard gun-metal frame, pivoted at top and bottom, the lower pivot resting on an end jewel, the upper pivot supported by a strong cast-iron gallows bracket, and it is driven by a contrate wheel in the clock train engaging into a pivot at the lower end of the frame. The frame is open, of the form shown in the right hand figure, to allow of the middle part of the axis of rotation being clear for the evolute and the pendulum string or rod. The evolute is fixed at M, and is capable of adjustment at right angles to the axis of rotation by a screw Q, the proper position of the curve in the other direction being practically secured by careful workmanship, more especially in the construction of the evolute itself. The pendulum consists of a spherical bob, weighing about $2\frac{1}{2}$ lbs., on a steel rod about one-tenth of an inch thick, and suspended by a long and *exceedingly thin* steel spring secured to the top of the evolute at N. The regulation of the length of the pendulum is done in the ordinary way by a nut at the bottom of the steel rod. The Governor thus made with ordinary care and workmanship is by far the best of any I have had experience of, and has furnished results better, I believe, than any others used with chronographs; at the same time it is simple and inexpensive. In the course of my experiments I found it quite necessary to use the most flexible suspension possible, and the thinnest steel spring made for French clock pendulum springs appears to answer well—it is not liable to twist unless the pendulum is started or stopped suddenly, and this is prevented by a guide for the bottom of the pendulum rod. To get the proper position of the evolute:—If the time of rotation increases with an increase of arc, in other words, if it revolves slower for increase of arc, the axis of the evolute is beyond the axis of rotation, reckoning from the centre of oscillation of pendulum (that is, it is too far away from pendulum bob); and it is too near if it revolves more rapidly for increase of arc. The adjustment

is somewhat tedious, more especially because for every alteration, however slight, of the evolute a large alteration of the length of pendulum is requisite—but it is easily done with a barrel chronograph by increasing and diminishing the driving power and noting the effect, on the rate, of increased and diminished arcs of pendulum. The screw which adjusts the evolute should be moderately fine, as the final touches necessary to get accurate performance will be found very small. I found a good deal of trouble in the course of my experiments from small particles of dust getting between the curve and spring, and it will be found quite necessary to protect the pendulum from this source of imperfect performance.

I had an opportunity of testing one of these chronographs in the presence of Professor Harkness, of the Washington Observatory. It was allowed to go for about an hour, then the weight was doubled for half an hour, and subsequently halved—the arc of the pendulum varying from 10° to 33° under these changes, but the *lines of seconds* on the barrel were quite undisturbed, and a fine straight line could be drawn so as to bisect every similar second mark. Professor Harkness was somewhat astonished and pleased with the result. I showed one or two sheets marked by this chronograph to Sir George Airy, Mr. Christie, Mr. Dunkin, and Captain Tupman, and I intended to show them at the meeting of the Society, but I unfortunately mislaid them. I have no doubt, however, these gentlemen will remember the exceeding precision with which the sheets were marked.

It may be said, however, that such great precision is unnecessary especially in astronomical chronographs, and that any of the ordinary means of obtaining moderately uniform rotation are sufficient for astronomical purposes. I shall be in a great measure inclined to agree with such an opinion, but not altogether, for these reasons. This Governor, which gives nearly perfect results, is simpler and cheaper than nearly all those which only aim at very moderate accuracy; and again, anyone who has had much to do with *reading off* chronograph sheets or fillets will, I am sure, agree with me that *time is saved enormously* where a *scale* of minutes and seconds can be applied to the register, which can only be done with confidence where the rotation has been uniform. In an Observatory where much transit work (especially in Zone-observing) is done with aid of the chronograph, as at Melbourne, any means by which *reading off* can be expedited is of much more value than many would be inclined to imagine. Again, a simple means of obtaining accurately uniform rotation will be of great value in driving siderostats, and in many physical and physiological experiments; and I do not imagine there would be any great difficulty in applying this method to governing the driving apparatus of Equatoreals, the uniform motion of which, I believe, yet remains a thing to be desired.

I have on the table an apparatus, a kind of Morse's telegraphic register, governed by a parabolic pendulum, which will illustrate my description. It is devised to draw a paper fillet over rollers with great uniformity for chronographic purposes.

On the Silvering of Glass by Inverted Sugar, for Optical Instruments and Experiments. By M. Adolphe Martin.

(Communicated by Warren De La Rue, D.C.L., F.R.S.)

Since my last publication of the process of silvering glass in *Les Mondes*, No. of 10th December 1868, I have found it useful to introduce the following modifications:—

We prepare four solutions, which, preserved apart, undergo no change:

- 1° A solution of 40 grammes of crystallised nitrate of silver, in a litre of distilled water.
- 2° A solution of 6 grammes of pure nitrate of ammonia, in 100 grammes of water.
- 3° A solution of 10 grammes of caustic potash (quite free from carbonate and chloride), in 100 grammes of water.
- 4° We dissolve 25 grammes of sugar in 250 grammes of water; we add 3 grammes of tartaric acid, and heat to boiling, which is maintained for about 10 minutes to produce the inversion of the sugar, and the solution is then allowed to cool. We then add 50 cubic centimetres of alcohol, to hinder any subsequent fermentation, and we dilute with water to make the volume half a litre if the silvering is to be done in winter, or dilute still more if it is to be done in summer.

We will take as an example the silvering of a mirror of ten centimetres diameter. On the surface of the glass, previously dusted with a brush of badger's hair, are poured a few drops of concentrated nitric acid, and, with the aid of a pad of fine carded cotton, free from extraneous substances, the glass is carefully cleaned, rinsed with water, and dried with a perfectly clean fine linen cloth. On the surface itself is made a mixture of about equal volumes of the potash solution (No. 3) and of alcohol, and this is used to clean the surface by means of a tuft of cotton. This liquid, of a somewhat syrupy consistence, has the property of wetting the glass without running off at the edge as other liquids would do. The surface thus covered is plunged into a vessel of tolerably pure water and well rubbed with a badger-hair brush to make the alkaline coating dissolve; the face is then turned downwards into a plate containing pure water, taking care that